Effect of .03% BAC and cumulative sleep deprivation on driving behaviour by age and sex:
a randomized placebo controlled experiment

Thomas G. Brown, Ph.D.[1,2]

[1]Douglas Hospital Research Centre
[2]Department of Psychiatry, McGill University, Montreal, Quebec, Canada

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Co-Investigators & Affiliations

- **Antoine Bechara, University of Southern California**

- **Reut Gruber, McGill University, Douglas Hospital Research Centre**

- **Marie Claude Ouimet, Université de Sherbrooke**

- **Jacques Tremblay, McGill University, Douglas Hospital Research Centre**

- **Junaid Bhatti, Sunnybrook Research Institute, Ontario**

Background

- **Road traffic crashes leading cause of mortality in young people**
  - $\approx$ **90% attributable to human factors**
    - **Recklessness**
    - **Speeding**
    - **Distraction**
    - **Driving while impaired**
    - **Fatigue, sleepiness**

Background

- **Low levels of alcohol use and sleepiness are both endemic in the young driver population**

- **Young drivers typically consume alcohol when sleepy – 21:00-3:00**
  - **Young drivers are twice as likely to be involved in crashes between 21:00-3:00 than older drivers**

Background: Alcohol

- **Adults: alcohol and sleep deprivation (SD) increase impairment synergistically**
- **Age effects in young drivers may increase overall risk**
  - **↓experience with alcohol, driving**
  - **↑ risk taking propensities**
    - **↓ executive function (<inhibition, impulsivity)**
    - **reward/incentive system activiation (>sensation seeking)**
- **Older drivers may be more susceptible to alcohol**

Background

- **Sex differences in alcohol's pharmacokinetics on safe driving capacities**
  - **Compared to males, females show:**
    - **↑ impairment of cognitive performance, (e.g., delayed memory, divided attention functions)**
    - **no greater psychomotor impairment**
    - **↑ impairment in driving performance at BAC = .65/kg**
      - **uncertain at low-moderate doses (e.g., Hoffman et al., 2015)**

Background: SD

- **Many forms of SD**
  - **restricted, involving 4-5 hours of sleep**
  - **total SD over a full night**
  - **cumulative, e.g., -1 hour of sleep over several nights**

- **Cumulative SD is pervasive yet little studied form of SD in young adults**

- **SD effects psychomotor and cognitive capacities similar to alcohol**

Background: SD

- **SD effects in RTC are poorly understood**
  - **hard to measure in road context**
  - **simulation studies focus on psychomotor capacities**
    - **cognitive factors related to risky decision making and risk taking are uncertain**
  - **age effects?**
  - **sex effects?**

Background: Alcohol + SD

- **Systematic study is lacking regarding impact on driving capacities of:**
  - **low dose alcohol and cumulative SD**
  - **age and sex effects**
  - **additive role on cognitive capacities leading to psychomotor impairment and risk taking**
    - **EC**
    - **cognitive control**

Principal research question

Does low dose alcohol (BAC 0.03%) and cumulative SD (1 hr/night X 6 nights) interact on the driving performance in younger vs. older, male vs. female drivers?

Hypotheses

- **H_1: Drivers under 0.03% BAC + SD perform significantly worse on a simulated driving task compared to drivers under either 0.03% BAC alone, SD alone, or 0.0% BAC + no SD.**

- *H_2: Under 0.03% BAC + SD, simulated driving performance deteriorates significantly more in drivers aged 18-21 years compared to drivers aged 22-25, 30-34.*

- *H_3: Under 0.03% BAC + SD, simulated driving performance deteriorates significantly more in females than males.*

- *H_E: Executive function and cognitive control mediate effects of alcohol and SD*

Design

- Controlled trials registration: ISRCTN81246006

- Between-subject randomized placebo controlled experiment

i. Stratification by age, sex

ii. Random assignment to 4 conditions and one comparator condition (BAC .05%)

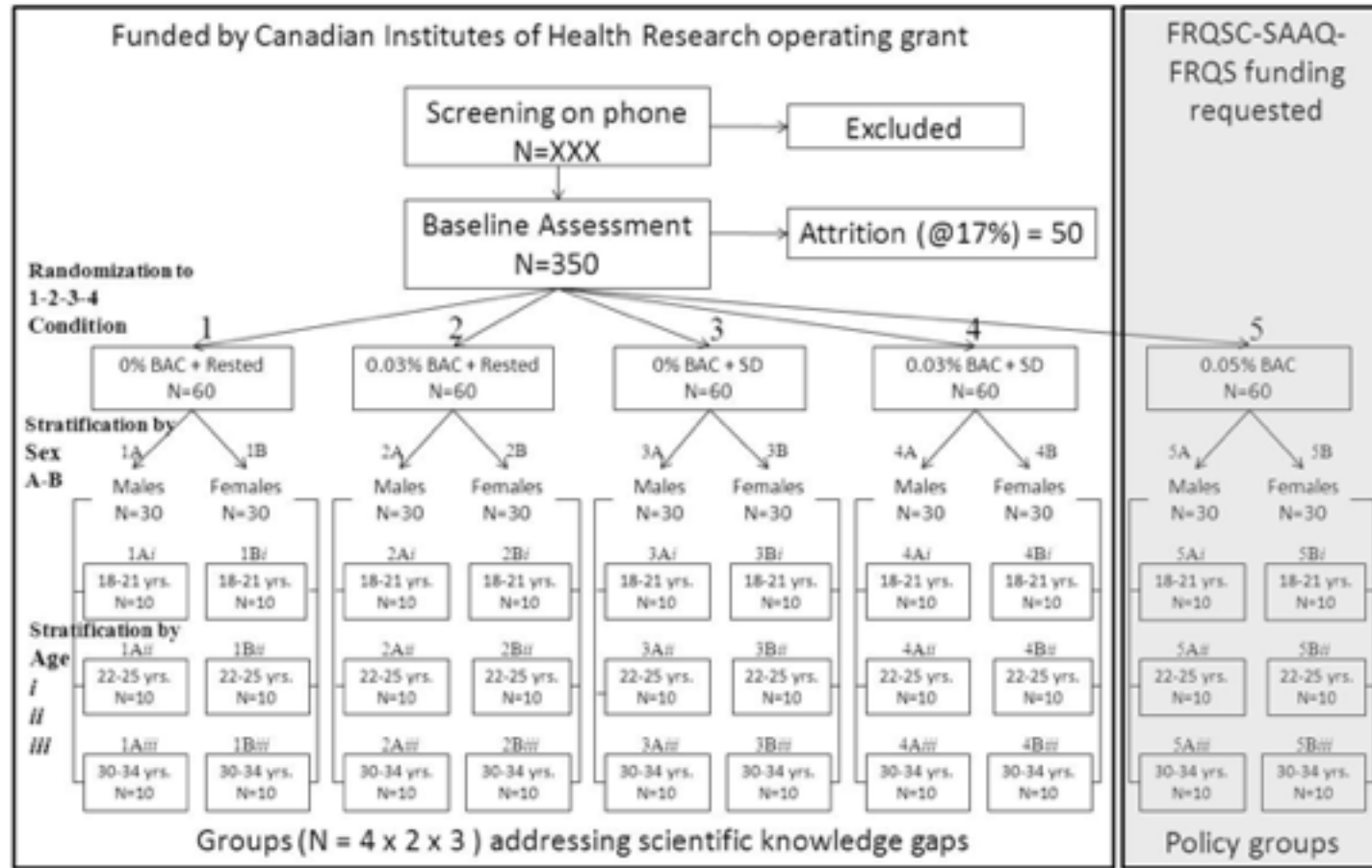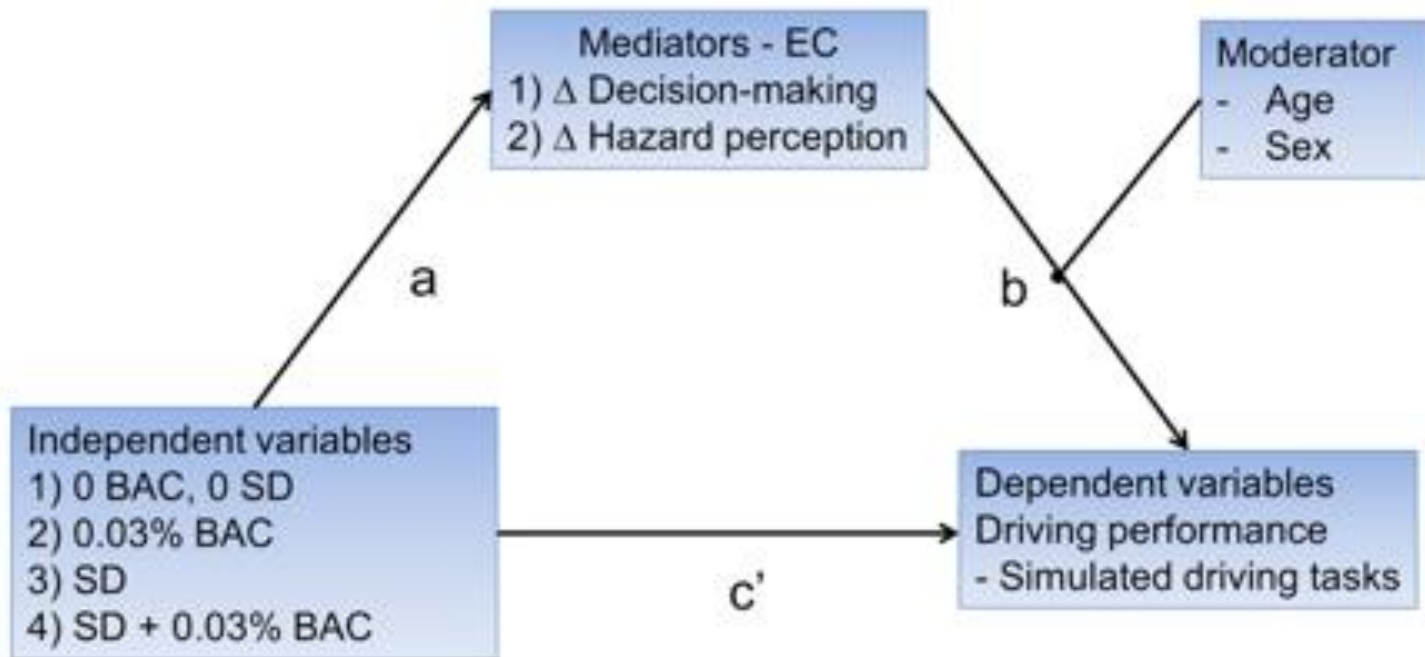iii. Placebo control for both alcohol and SD

Figure 1. Study Flow Through and Random Assignment and Stratification

Design

Figure 2. Conceptual model

Exploratory analyses of expected influences of Sleep Deprivation (SD) and 0.03% Blood Alcohol Concentration (BAC) on driving performance expected to be moderated by age and gender and mediated by Executive Control (EC)

Procedures

Session	Phone screening	Baseline recruitment, assessment		Actiwatch® data collection		Experimental session
		Day 0		Day 6		≈Day 13
Duration						
- 10-15mins	Demographics, PSQI, AUDIT, DUDIT, BDI, health screening					
Time						
- 1100-1129hrs		Arrival, Consent forms, Snacks*			S	Arrival, Snacks*
					D	
- 1130-1150hrs		Confirm –ve BAC, Drugs, Pregnancy & detailed health screening				Confirm –ve BAC, SD, Drugs, Pregnancy
			5	A	I	
- 1151-1200hrs		Simulation practice	Day	N	N	Simulation practice
				Y	D	
- 1200-1215hrs		Driving questionnaires	N		U	**Alcohol dosing, monitoring begins**
			O	T	C	
- 1216-1255hrs		UPPS – I	R	I	T	≈Achieve 0.03% BAC
			M	M	I	
- 1256-1314hrs		Break, Light snacks*	A	E	O	Break, Light snacks*
			L		N	
- 1315-1345hrs		IGT		5-10 min approx.		IGT
					F	
- 1346-1415hrs		CPT			O	CPT
			S		R	
- 1416-1445hrs		Baseline Simulation	L			Simulation task 1
			E		7	
- 1446-1514hrs		Briefing & Actiwatch intructions	E			Simulation task 2
			P		D	
- 1515hrs		Session end			A	Debriefing (performance perception)
			D		Y	
- 1530hrs			A		S	Waiting period (until BAC=0)
			T			
- 1601hrs			A			Session end

AUDIT — Alcohol Use Disorders Identification Test
BAC — Blood Alcohol Concentration
BDI — Beck Depression Inventory II
DUDIT — Drug Use Disorders Identification Test
IGT — Iowa Gambling Task
CPT — Continuous Performance Test
PSG — Polysomnography
PSQI — Pittsburgh Sleep Quality Index
SD — Sleep deprivation

UPPS-1 — Urgency, Premeditation (lack of), Perseverance (lack of), and Sensation seeking (UPPS) Impulsive Behavior Scale 1
* — E.g. cheese rolls

Figure 3.

Variables

- **IVs**
  - **Alcohol dose: 0.0% (placebo), .03%, .05% (ref)**
  - **SD: placebo, SD**

- **Driving simulation DVs (for this presentation)**
  - **Errors: lane keeping**
  - **Violations: mean speed**

- **Moderators**
  - **Age, sex**

- **Mediators (for this presentation)**
  - **executive function: impulsivity (Continuous Performance Task)**
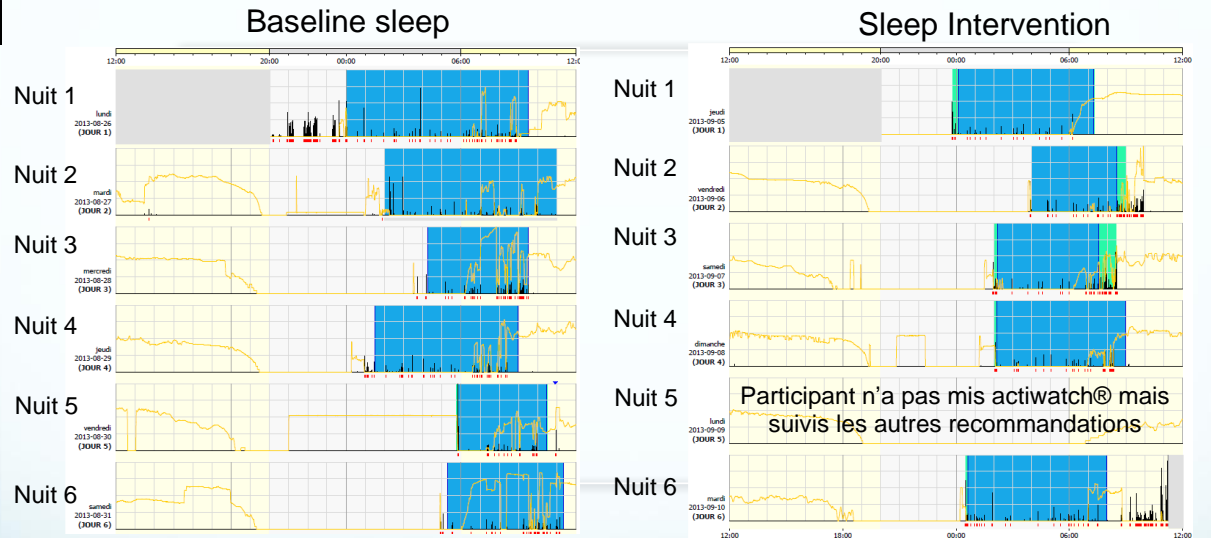 - **cognitive control: decision making (Iowa Gambling Task)**

Methods

Figure 4. Objective manipulation of BAC
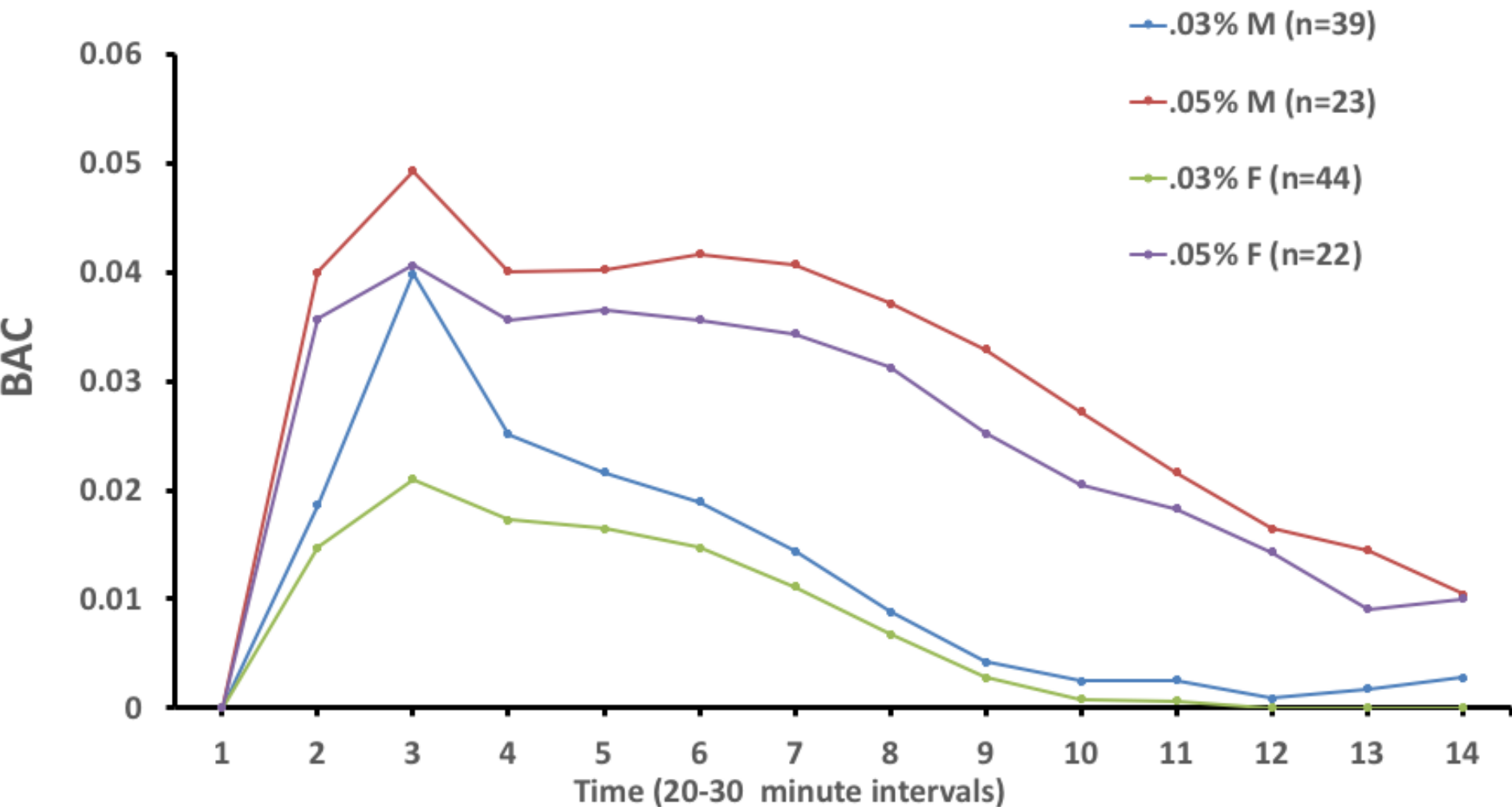
Methods

Figure 5. Actigraphy

Exemple de données actiwatch® : pilote n°3

Baseline sleep

Nuit	Heure de début	Heure de fin	Durée (en minutes)
1	00:02:00	09:29:00	567
2	02:00:00	10:59:00	539
3	04:15:00	09:29:00	314
4	01:31:00	08:59:00	448
5	05:52:00	10:29:00	277
6	05:20:00	11:19:00	359
Moyenne	03:10:00	10:07:20	417 (≈ 6,9h)

Sleep Intervention

Nuit	Heure de début	Heure de fin	Durée
1	00:08:00	07:19:00	431
2	04:00:00	08:31:00	271
3	02:13:00	07:34:00	321
4	02:10:00	08:59:00	409
5	Participant n'a pas mis l'actiwatch®		
6	00:38:00	07:59:00	441
Moyenne	01:49:48	08:04:24	374,6 (≈6,2h)

Methods

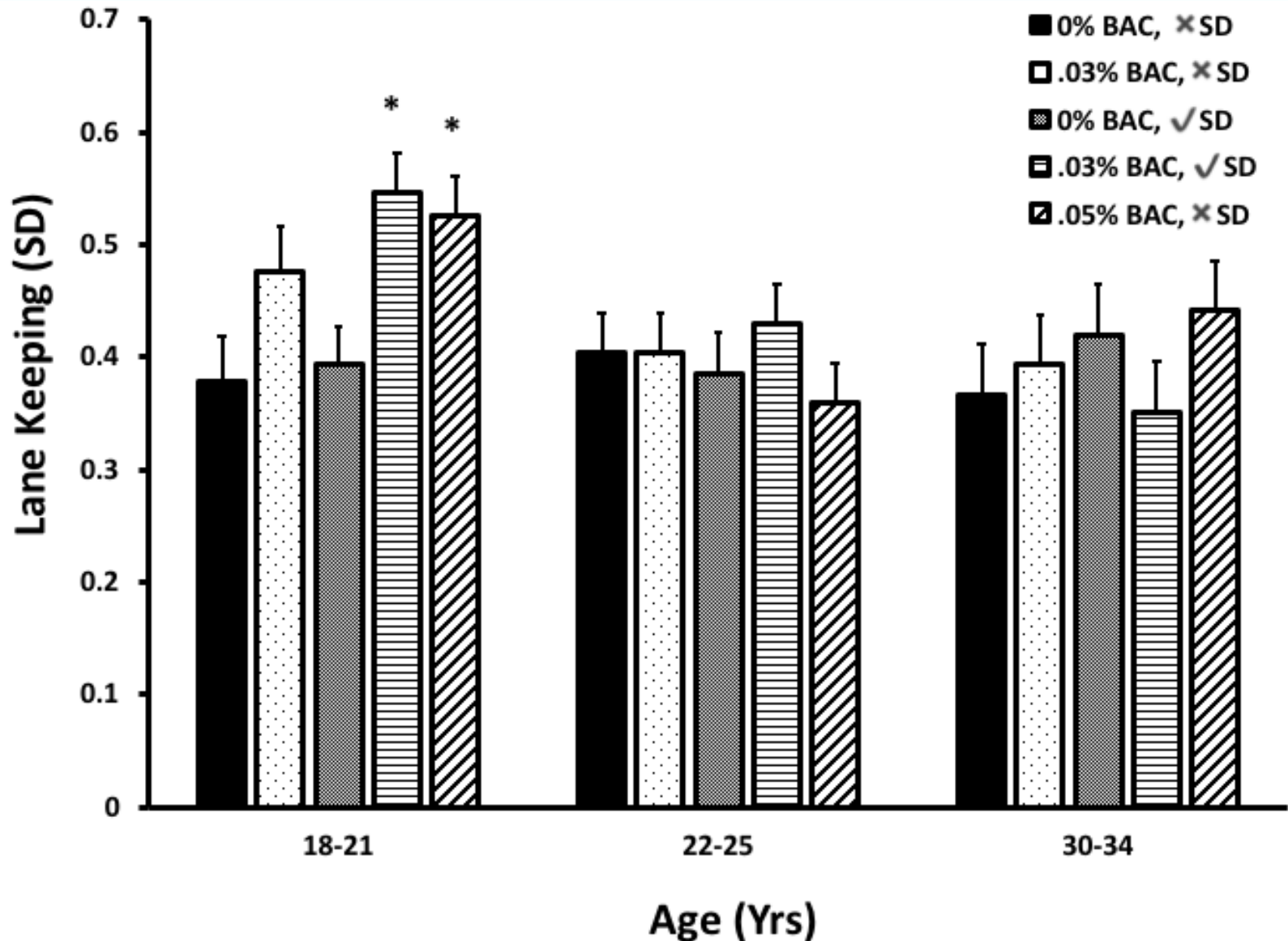**Figure 6. SD vs placebo conditions, in average hours of actual sleep time (n = 261); 4.5 hours less with SD.**

Sleep intervention

Visit 3

Methods

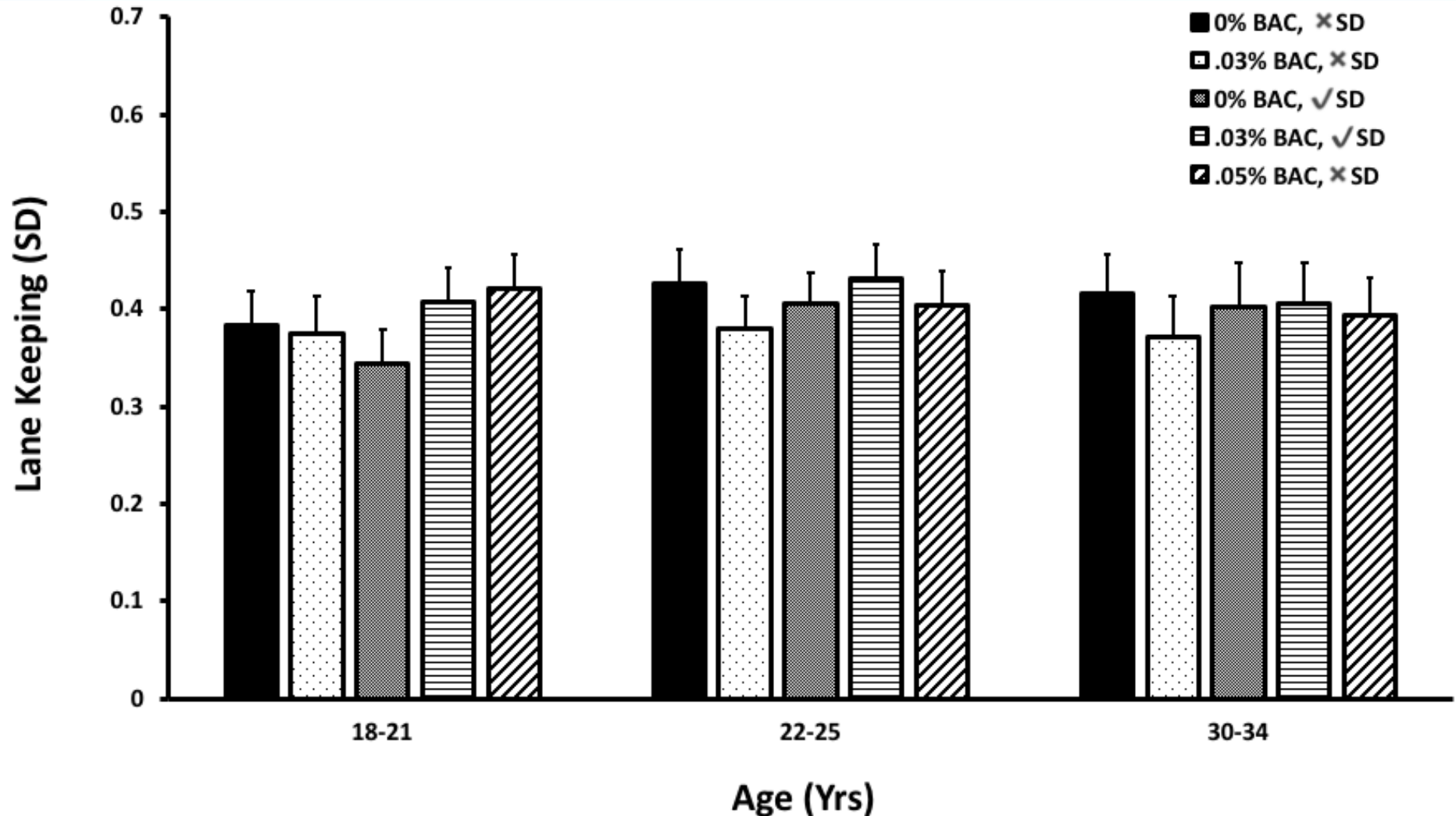## Figure 7. DV: Driving simulator set-up and drives

Results: Driving performance
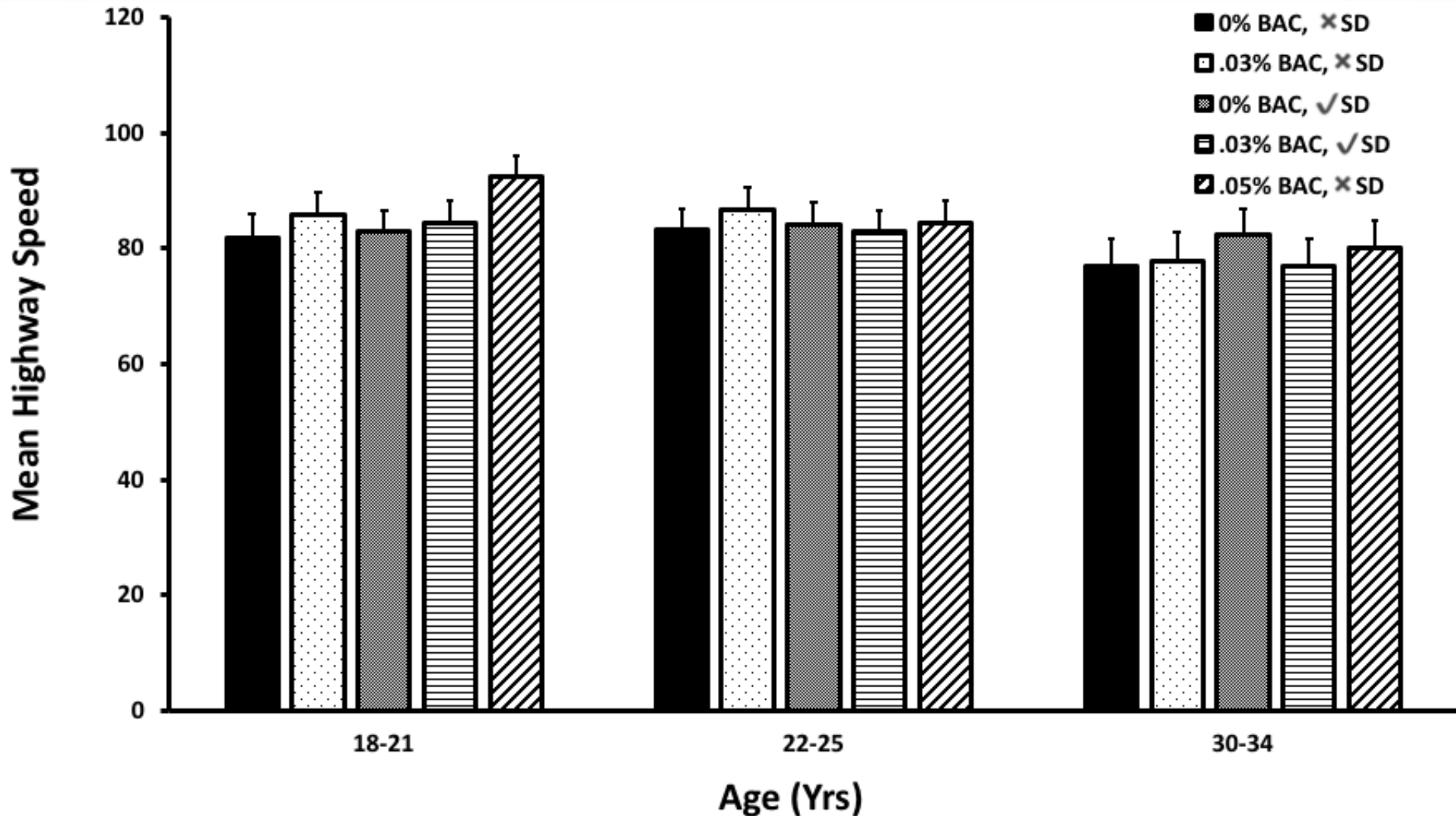## Figure 8. Males: Lane keeping

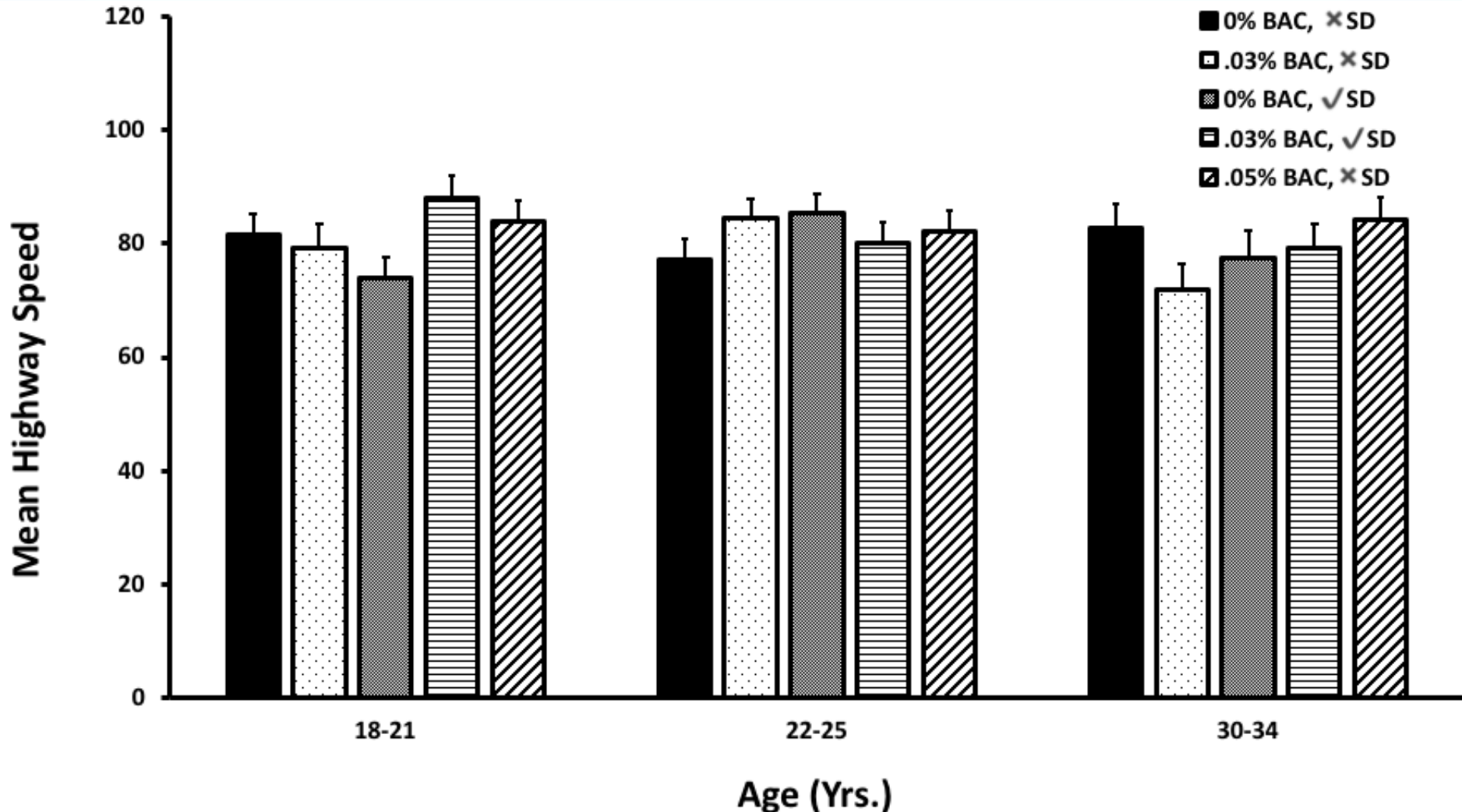# Results: Driving performance
Figure 9. Females: Lane keeping

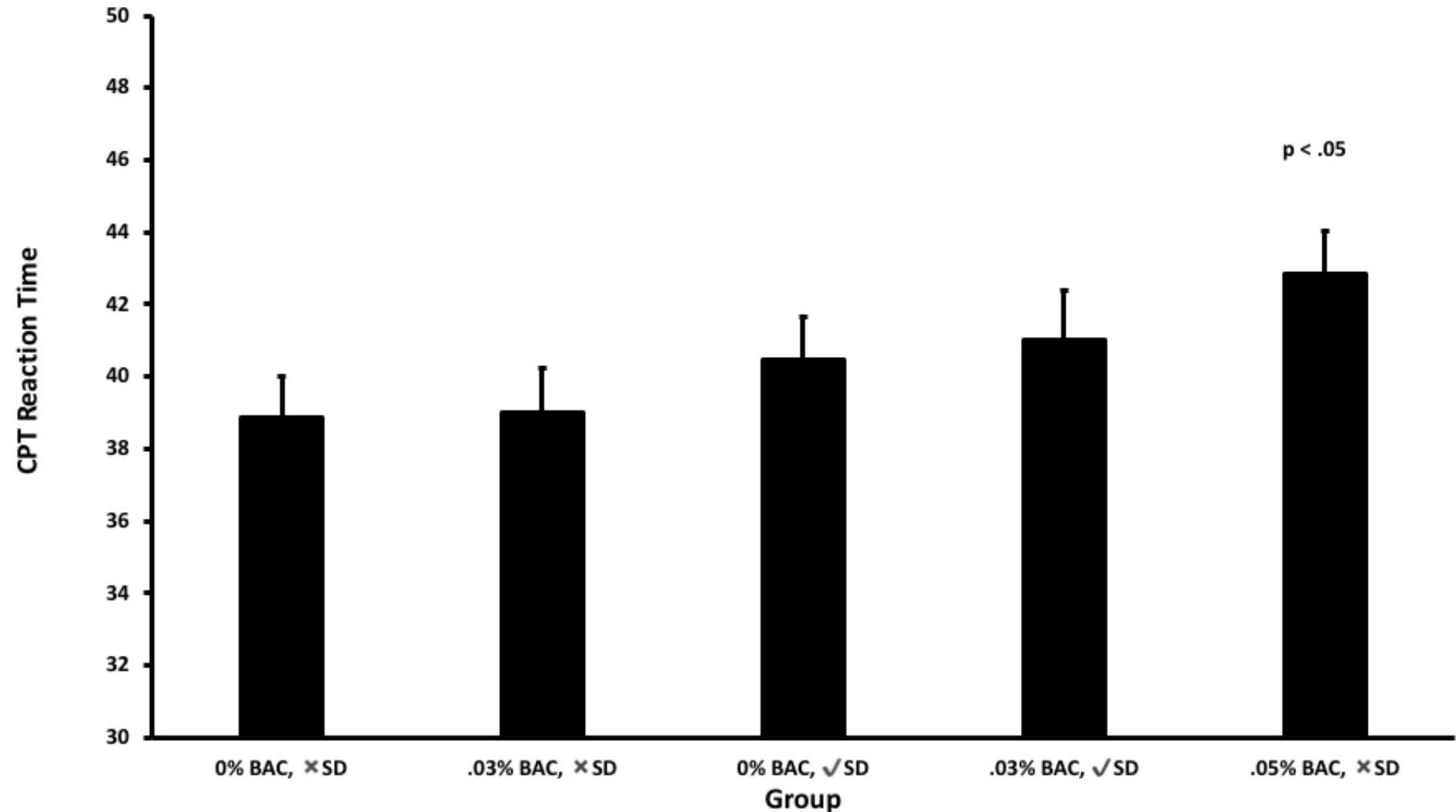# Results: Driving performance
Figure 10. Males: Speed

Results: Driving performance
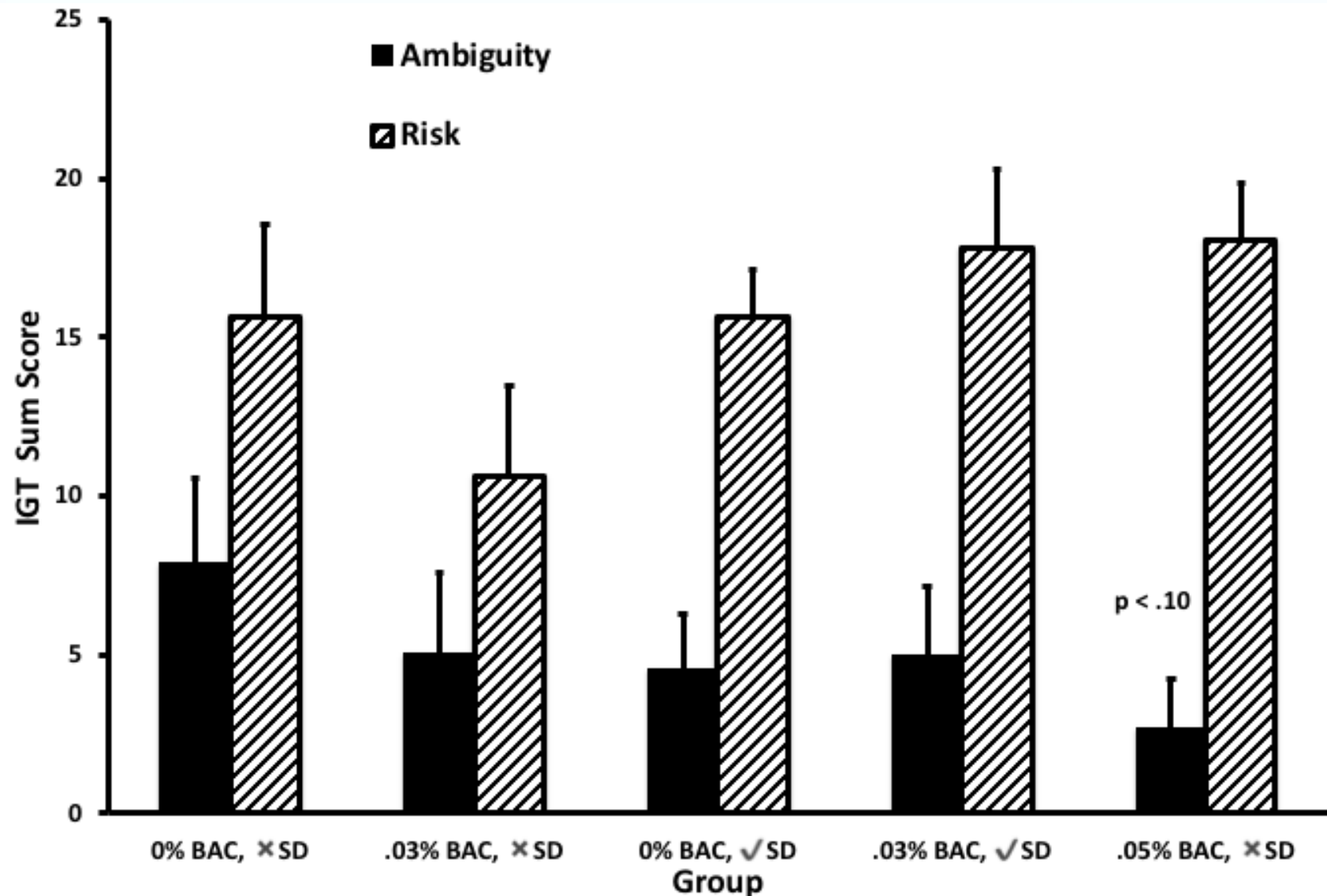## Figure 11. Females: Speed

Results: Executive function

Figure 12. Impulsivity: Continuous Performance Task Reaction Time

Results: Cognitive control
Figure 13. Decision making: Iowa Gambling Task

Discussion

- **Limitations**
  - **Preliminary analyses of restricted set of variables**
    - **Generalizability of results from simulator to the RCT can be questioned**
      - **Some support for validity of speed and aggressive driving behaviour on this simulator to on-road behaviour (Brown et al., 2016)**
  - **Manipulations of conditions were objectively monitored and produced anticipated main effects**

Discussion

- **Main finding (so far)**
  - **Supported H_2, youngest drivers are most susceptible to combined low dose alcohol and cumulative SD**
    - **impairment similar to BAC .05%**
      - **illegal in many jurisdictions**
      - **associated with crash and injury risk**

- **Testing of putative mediators of this effect to follow**

Discussion & Implications

- **Cumulative SD is subtle and hard-to-prohibit form of driving impairment**

- **Alcohol intake easier to prohibit and enforce than SD**
  - **Zero tolerance for alcohol in young drivers is warranted in light of potential SD**
  - **Despite restricted licensing strategies, young drivers still at risk for low dose alcohol consumption**

- **More pointed messaging highlighting additive role of cumulative SD in the context of low alcohol doses seems worthy of consideration**

Thank you